* Demodulation of D.S.B.S.C. :

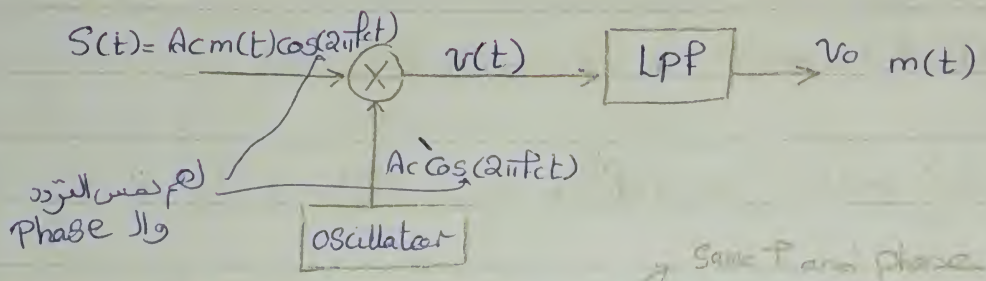
أي عملية إستخلص $m(t)$ من $S(t)$.

1 Coherent demodulation :

Coherent means that the local oscillator signal is sync. with Sc

في هذه الحالة سوف نستخدم oscillator له خرج $A_c \cos 2\pi f_c t$ أي عبارة عن cos

له نفس التردد و الـ phase مثل $c(t)$



* assume that oscillator's o/p is coherent & Sync to the modulated carrier → same F and phase

let $S(t) = A_c\, m(t) \cos(2\pi f_c t)$

$$v(t) = S(t) * A_c \cos(2\pi f_c t)$$

$$= (A_c\, m(t) \cos(2\pi f_c t))(A_c' \cos(2\pi f_c t))$$

$$= A_c A_c' \cdot m(t) \cdot \cos^2(2\pi f_c t)$$

$$= A_c \cdot \frac{A_c'}{2} \cdot m(t)\,(1 + \cos(4\pi f_c t))$$

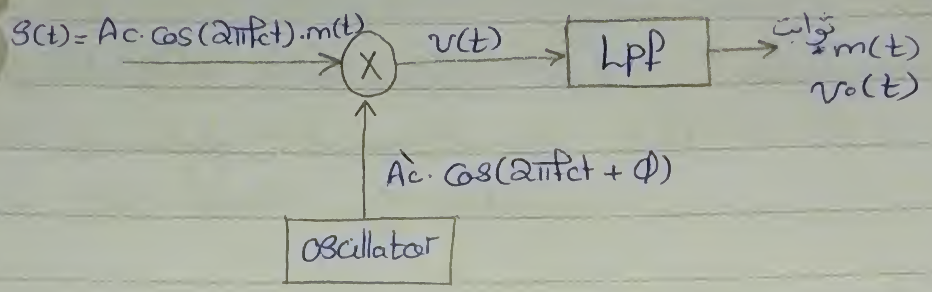
↑ ضعف التردد

$$v(t) = \underbrace{\frac{A_c A_c' m(t)}{2}}_{\text{مطلوب}} + \underbrace{\frac{A_c A_c' m(t)}{2} \cdot \cos(4\pi f_c t)}_{\text{غير مطلوب}}$$

After LPF

$$v_o = \frac{A_c A_c'}{2} \cdot m(t)$$

* If the local oscillator's output is not exactly coherent with $c(t)$ & has a phase shift ϕ from the carrier phase.



$$v(t) = A_c \cdot \cos(2\pi f_c t) \cdot m(t) * A_c' \cos(2\pi f_c t + \phi)$$

$$= \frac{A_c \cdot A_c' \cdot m(t)}{2} \left[\cos(\phi) + \cos(4\pi f_c t + \phi) \right]$$

$$\cos(m) \cdot \cos(n) = \frac{1}{2} \left[\cos(m-n) + \cos(m+n) \right]$$

ثابت ($\cos(\phi)$)

$$= \frac{A_c \cdot A_c'}{2} m(t) \cos(\phi) + \frac{A_c A_c'}{2} m(t) \cos(4\pi f_c t + \phi)$$

الجزء المطلوب الذى يحتوى $m(t)$ وهعديه بـ LPF

الجزء المرفوض الذى سيمنعه الـ LPF

$$v_o(t) = \frac{A_c \cdot A_c'}{2} m(t) \cos(\phi)$$

→ if $\phi = 90^\circ$ → $V_o(t) = 0$

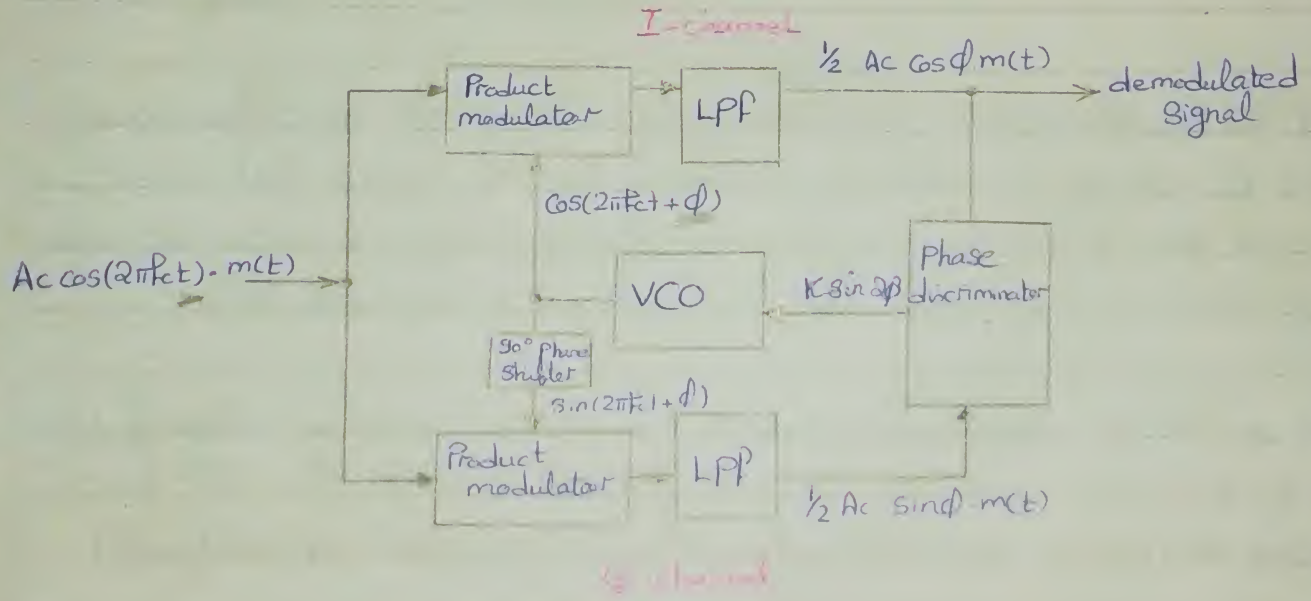
Square loop

[2] Costas Receiver

- Practical Synchronous receiving system "Sync. means that it tends to make the oscillator's o/p phase equal to S(t) phase".

- The System contains. two Coherent detectors
  - phase discriminator "multiplier + LPF"

- A Voltage-Controlled Oscillator (VCO) is a device whose output frequency depends on its input voltage.



- First, if the oscillator's o/p is of the same phase as the incoming DSBTC wave then, the I-channel will have the desired m(t) signal and the Q-channel will have Zero signal

I-channel $A_c \cdot \cos(2\pi f_c t) \cdot m(t) \cdot \cos(2\pi f_c t) = \frac{A_c}{2} m(t) \left(1 + \cos(4\pi f_c t)\right)$

$= \underbrace{\frac{A_c}{2} m(t)}_{\text{Pass through LPF}} + \frac{A_c}{2} m(t) \cos(4\pi f_c t)$

Q-channel

$$A_c \cdot \cos(2\pi f_c t)\, m(t) \sin(2\pi f_c t) = \frac{A_c \cdot m(t)}{2}\left[\sin(0) + \sin(4\pi f_c t)\right]$$

$$= \underbrace{\frac{A_c \cdot m(t)}{2} \cdot \sin(4\pi f_c t)}_{\text{تمر من الـ LPF}}$$

∴ o/p of LPF will be ~~zero~~.

- The oscillator cos signal is phase shifted by 90° so, it is shifted into a Sine wave, a signal and its 90° shifted signal are called in phase Quadrature

- If, the oscillator's o/p is shifted by a small angle ϕ (Phase), the costas receiver tends to reduce this shift by using a -ve F.B. system that takes part of the I-channel o/p & the Q-channel o/p into phase discriminator which produces a dc signal that is proportional to the phase shift

- This dc value automatically controls this phase error and reduce it.

I-channel

$$A_c \cos(2\pi f_c t)\, m(t) \cdot \cos(2\pi f_c t + \phi) = \underbrace{\frac{A_c \cdot m(t)}{2}\left[\cos(\phi) + \cos(4\pi f_c t + \phi)\right]}_{\text{through LPF}}$$

Q-channel

$$A_c \cdot \cos(2\pi f_c t)\, m(t) \cdot \sin(2\pi f_c t + \phi) = \underbrace{\frac{A_c \cdot m(t)}{2}\left[\sin(\phi) + \sin(4\pi f_c t + \phi)\right]}_{\text{through LPF}}$$

At phase discriminator

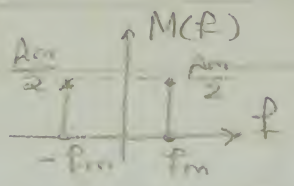
$$\frac{A_c}{2} m(t) \cos\phi \;*\; \frac{A_c}{2} m(t) \sin\phi = \frac{A_c^2 m^2(t)}{4} \cdot \frac{1}{2}\left[\sin(0) + \sin 2\phi\right]$$

$= \frac{A_c^2 m^2(t)}{8} \sin 2\phi$.

↳ this term will through LPF and dc Part will only pass. and the o/p of it will be $K \cdot \sin(2\phi)$.

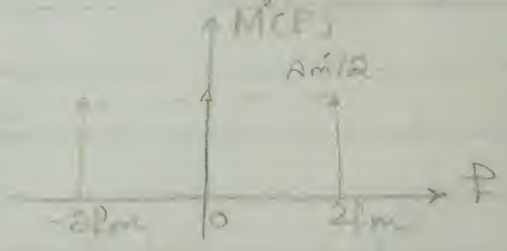
Note:-

assume $m(t) = A_m \cos(2\pi f_m t)$



$m^2(t) = \frac{A_m^2}{2}(1 + \cos 4\pi f_m t)$

$\therefore M^2(f) = \frac{A_m^2}{2}\delta(f) + \frac{A_m^2}{2}[\delta(f-2f_m) + \delta(f+2f_m)]$

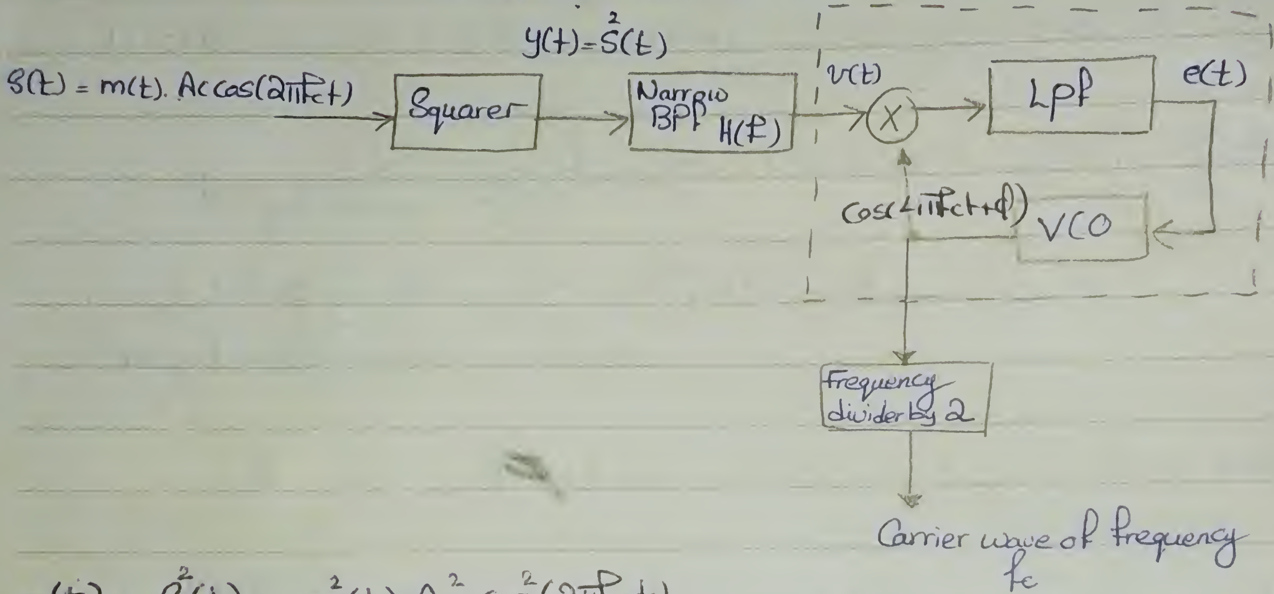


∴ LPF will pass the delta component at $f=0$ which will be $K \sin(2\phi)$.

تابع Demod. of DSBSC

Squaring loop

الهدف منها عمل Carrier لها نفس ال f و ال Phase بتاع ال Carrier
في الإشارة المستقبلة لعمل Coherent detection لها تماماً.



$$y(t) = s^2(t) = m^2(t)\,A_c^2 \cos^2(2\pi f_c t)$$
$$= \frac{A_c^2}{2}\,m^2(t)\,[1 + \cos(4\pi f_c t)]$$

$\cos(4\pi f_c t)$ → will pass

- after the BPF which is centered at $2f_c$.

$$v(t) = \frac{A_c^2}{2}\,E\Delta f \cos(4\pi f_c t)$$

- $v(t)\cdot\cos(4\pi f_c t + \phi)$
$$= \frac{A_c^2}{2}E\Delta f.\ \frac{1}{2}\left[\cos(\phi) + \cos(8\pi f_c t + \phi)\right]$$

$\cos(\phi)$ → through LPF

- $e(t) = K\cdot\cos\phi$
  which will adjust the VCO until its o/p is $\cos(4\pi f_c t)$ → has $f = 2f_c$
- The desired freq. is then f_c after division by two.